Extraordinary Architectural Design Requirements For Combined Explosive and Chemical Agent Disposal Operations

Presented at the 26th Annual DOD Explosive Safety Seminar

by

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Introduction

The Chemical Stockpile Disposal Program (CSDP) was established by Congress to destroy the nation's inventory of unitary chemical weapons. The program Manager for Chemical Demilitarization, Edgewood, Maryland has the overall responsibility to develop and operate the disposal processes. The Huntsville Division, corps of Engineers is responsible for design and construction of the disposal plant facilities.

Background Information

The stockpile of unitary chemical weapons contains five different lethal agents. The explosively configured weapons are rockets, mortars, mines, 105 mm, 155 mm, and 8 in. projectiles and three types of bombs. The agents are also stored in spray tanks and bulk containers that are non-explosive. The mix of five agents and eleven configurations results in twenty different weapon types to be destroyed. These weapons, World War II vintage and older, are stored at eight locations in the continental United States and on Johnston Atoll in the Pacific Ocean. A disposal plant is to be built immediately adjacent to each storage site. This minimizes the hazards associated with handling and transporting the munitions and they will not be transported outside of the highly secure storage and disposal site.

After several years of developmental design and testing, a process called reverse assembly and incineration has emerged as the preferred method of disposal. In this process, automated conveyors, material handling equipment and disassembly machines drain the liquid agent, separate the explosives and propellants and prepare the components for incineration in four separate furnace systems. The dunnage furnace receives all packing materials that the munitions are stored in. Energetic materials are fed to the deactivation furnace. Liquid chemical agent is drained to a holding tank then pumped at a controlled feed rate to the liquid

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incinerator. Munition bodies and other metal components pass through the metal parts furnace to burn out all chemical agent residue. The advantages of this method include ability to control feed rates to the furnaces assuring complete incineration, separation of waste streams for proper disposal of solid residues and predictability of the furnace exhaust gas composition that must be treated in pollution abatement systems before release to the atmosphere.

Two plants have been built to date. The first, on Johnston Atoll, is now fully operational. Construction of a plant in Utah was completed this year and is currently undergoing systems testing.

Design Criteria

Explosive safety and explosion containment are major requirements for any munitions facility. In CSDP, containment of chemical agent in liquid and vapor form is even more critical. The combination of explosives and toxic environment presents concerns for life safety that NFPA 101 does not begin to address. Similarly, the Uniform Building Code has minimal applicability to CSDP because, in most instances, the code requirements are less stringent than the program criteria. Some of the safety criteria, particularly in seismic design, was taken from the nuclear power industry. Army regulations for security of chemical agent impose further requirements that play tug-of-war with life safety criteria.

Explosion Containment

Explosively configured munitions are delivered to the second floor unpack area and placed on conveyors. From there they pass through a blast gate into an explosion containment room (ECR) where the energetic materials are removed.

There are two ECRs are constructed of 25 inch thick reinforced concrete with a very high percentage of steel. Each EAR has two large, heavy steel blast doors for maintenance access and to change tooling for different types of munitions. An “Architectural”" feature not seen in our daily surroundings is a steel fragmentation shield that protects a mass of piping and conduct penetrating the ECR Wall in case a bad boy munition objects to the disassembly treatment and misbehaves.

Explosives and propellants go into a feed chute to the deactivation furnace system (DFS) below. Blast gates in the feed chute have the udal role of blast containment and controlling the feed rate to the furnace. The DFS is also in an explosion containment room that has 20 in. thick walls and blast doors. All operations related to explosives, from first step of disassembly to final destruction, occur within these ECRs.

Agent Containment

Each room in the MDB is assigned a letter code that defines the probable levels of chemical contamination and ventilation requirements. The contamination categories are:

A - any space where the presence of liquid agent is probable.

B - any space where the presence of agent vapor is probable.

A/B - any space where either condition could occur.

C - any space where the presence of agent is possible but unlikely or infrequent.

D - any space where the presence of agent vapor is unlikely and would occur only by an incident causing a site wide release.

E - any space designed to prevent the presence of agent in any form.

The MDB is designed with a cascading ventilation system where air is supplied to C spaces then drawn inward, through transfer ducts with volume control dampers, to B, then A spaces. The air is exhausted through a series of charcoal filter banks to remove all traces of agent before release to the atmosphere. Category D spaces such as entry vestibules and non-process mechanical and electrical equipment rooms are maintained at atmospheric pressure. Most C spaces are at -0.25 inches water column. Each successive space along the air stream is at an increasingly negative air pressure, some category A spaces are in the order of -1.5 to - 2 inches water column. The MDB central control room and the medical treatment facility are category E spaces maintained at positive room air pressure. Supply air to E spaces is pretreated through charcoal filters to remove all traces of chemical agent in the event that a mishap could release agent anywhere on the site.

Periodically, chemically contaminated areas of the building must be washed with decontamination solutions. In general, C areas are washed down promptly whenever contamination occurs. A and B areas are decontaminated prior to maintenance and repair activities and equipment changeover to process a different type of munition.

Agent containment imposes strict criteria for building design that include:

Void free construction to eliminate concealed spaces where agent or agent vapor could be trapped is required for all A, B, A/B and C spaces.

Construction joints through which agent, agent vapor, or decontamination solutions could leak must be minimized.

Air infiltration that could affect the cascade ventilation system must also be minimized.

No dead level surfaces where agent or decontamination solutions could stand are permitted.

Walls must withstand differential air pressures between the rooms.

Materials and finishes must be impervious and non-reactive to the various chemical agents and decontamination solutions.

The integrity of walls, floors and ceilings at all penetrations must be maintained to prevent leakage.

Floor, roof and structural frame are cast-in-place reinforced concrete with the location of construction joints carefully controlled. All exterior and interior walls are either cast-in-place concrete or steel faced, foam filled, tongue and groove composite wall panels. Concrete walls are used where shear walls, explosion containment or fire ratings are required. All openings in concrete walls are framed with embedded channels. The composite panel walls are mounted on 6 inch high concrete curbs to contain spills and decontamination solutions. The panels are supported on square steel tube framing with continuous, full penetration welds at all connections including framing for all wall openings. Door frames, window frames and penetration plates are seal welded to the embedded channels or tube steel framing. All surfaces are painted with an epoxy type coating tested for resistance to the various chemicals and solutions to which it will be subjected.

Four inch high curbs are provided at all door openings. Door frame sections used at the sill increases the effective curb height to six inches. The sill frame section is filled with cement grout to prevent damage or deformation; jamb and head sections are filled with foam or grout to eliminate internal voids. Doors are fully gasketed at head, sill and jambs to prevent air or fluid leakage.

Security

Army security regulations for chemical weapons are very stringent for obvious reasons. These regulations, primarily covering storage, handling and maintenance of the weapon stockpile, were rewritten and expanded to include CSDP operations. Site security for the storage area and disposal plant requires double fences separated at least 30 feet and fully covered with an intrusion detection system. Additional 30 ft. wide clear zones are required on each side of the fences. No vegetation is allowed within this 90 ft. wide clear zone.

Any area within the building where recoverable chemical agent may be present is defined as an exclusion area. One of the security requirements is a two man rule for entering an exclusion area. This rule, in part, prompted rewriting the security regulations. The previous reg defined the exclusion area as the entire building containing chemical agent and imposed two man rule to maintain mechanical and electrical equipment located in non-process category D spaces. The revised regulation allows free access to all non-process/non-storage category D portions of the building and category C observation corridors and monitor rooms.

All doors in the exclusion area perimeter must be secured either by bolting on the interior side to prevent entry or with two high security, shrouded hasps and padlocks. Other openings such as windows, duct penetrations and glazed panels in doors that exceed 96 square inches and 6 inches in the least dimension must be protected with steel grilles. All such doors and

openings have intrusion detection devices.

Life Safety

Protection of Operating personnel is extremely important. The two man rule imposed for security proposes is also a buddy system when working within the exclusion are. Normal entry and exit routes to toxic areas are through a series of airlocks. Workers are sealed into protective clothing and connected to life support air hoses before entering. Door frames are provided with special hose support assemblies to allow the hoses to pass through closed doors without air or agent vapor leakage. The airlock doors are equipped with electro-magnetic locks that prevent simultaneous opening of two doors to the room. On entry, the succeeding door is locked until the door entered is fully closed. On exiting, the succeeding door is locked and remains locked for 120 seconds after the preceding door has closed. The two minute delay allows two complete air changes in the occupied airlock before the next door is opened. During the delay time in the inner airlock the workers are showered with decontamination solution. In the middle airlock they are monitored for presence of agent on their protective clothing. If free of agent they are assisted in removing the outer suit, then exit to the next airlock. The 3 airlock sequence, each having a two minute delay, is not suitable for emergency evacuation.

Two types of emergency escape routes are provided. One type, defined as an emergency exit, is equipped with exit only panic hardware and is located to provide the shortest route to the building exterior. Emergency exits do not have any exterior hardware trim to allow entry, therefore they do not require the high security hasps and padlocks.

Although most of the disposal process is automated and remotely operated, the second floor unpack area requires intensive manual tasks to unload the transport containers and place munitions on the feed conveyors. the unpack area has four emergency exits with exterior slide chutes to the ground. The maximum travel distance to an emergency exit in the unpack area is approximately 40 feet.

The other type of escape route is defined as an emergency door. Workers in the exclusion must be observed at all times either by direct visual contact or closed circuit television. Exterior hardware trim on emergency doors are a pull handle and key cylinder to retract the latchbolt. This allows entry to assist or rescue an injured or incapacitated worker. Because entry through emergency doors is possible, they must have the dual hasps and padlocks. The padlocks are removed and observers/rescuers are in place before entry to an exclusion area is made.

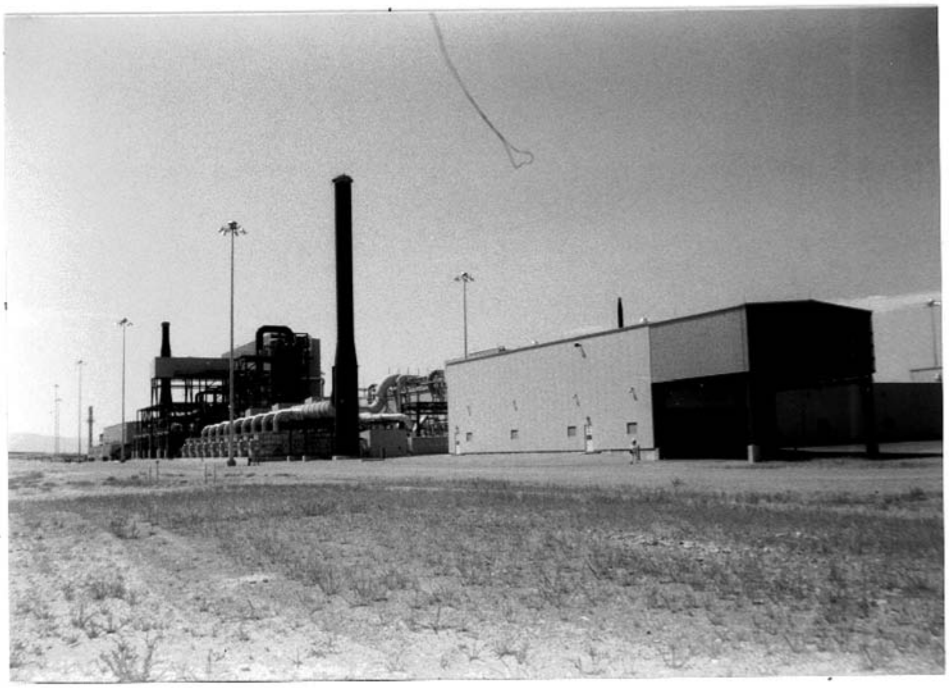
The cascade ventilation system exerts a vacuum pressure on most doors. Whenever a force of 30 lbs. or more is required to break the vacuum, a pneumatic power assist operator is provided. The air supply, operating at 80 to 100 psi, has sufficient residual pressure to evacuate the building in event of power loss or compressor failure. The doors, hardware and

control systems have extraordinarily complex interactions. A bias magnetic switch signals the control room whenever a door is open and activates automatic control of the magnetic locks. Exit devices, locksets and latchsets, installed on doors with power assist, must be modified to provide a pneumatic switch that activates the power assist after the latchbolt is fully retracted. A flexible loop connects the air supply to tubing concealed in the door which connects to the pneumatic switch. Doors with power assist and magnetic locks have a solenoid valve in the air supply that closes whenever the magnetic lock is energized.

Current Status/Future Direction

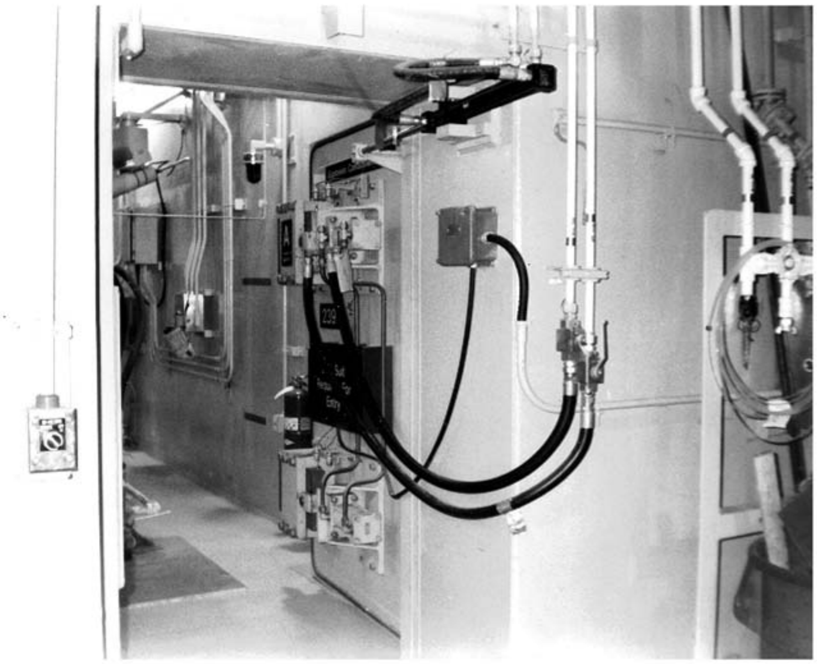
The rigorous, demanding CSDP criteria extends the theory of "form follows function[1] to extremes never envisioned by the early practioners of modern, 20th century architecture. Lessons learned from the Johnston Atoll and Utah sites are being used to improve the design for the seven other sites.

View of Utah plant looking southwest. Maunitons receiving dock in foreground.



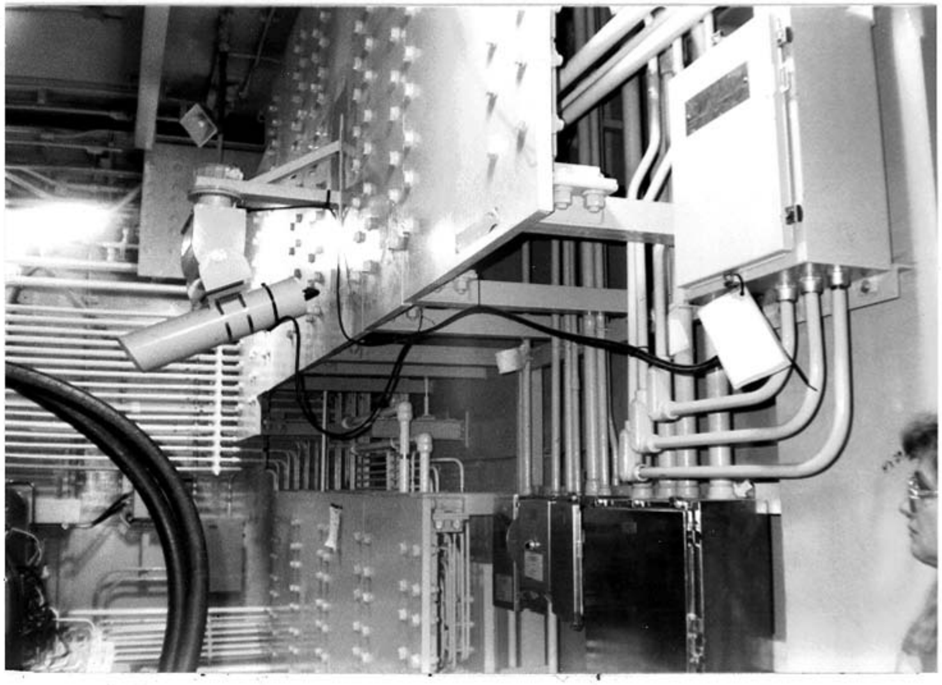
View of Utah plant looking southwest .
Maunitons receiving dock in foreground.

ECR blast door.



ECR blast door.

Fragmentation shield in ECR

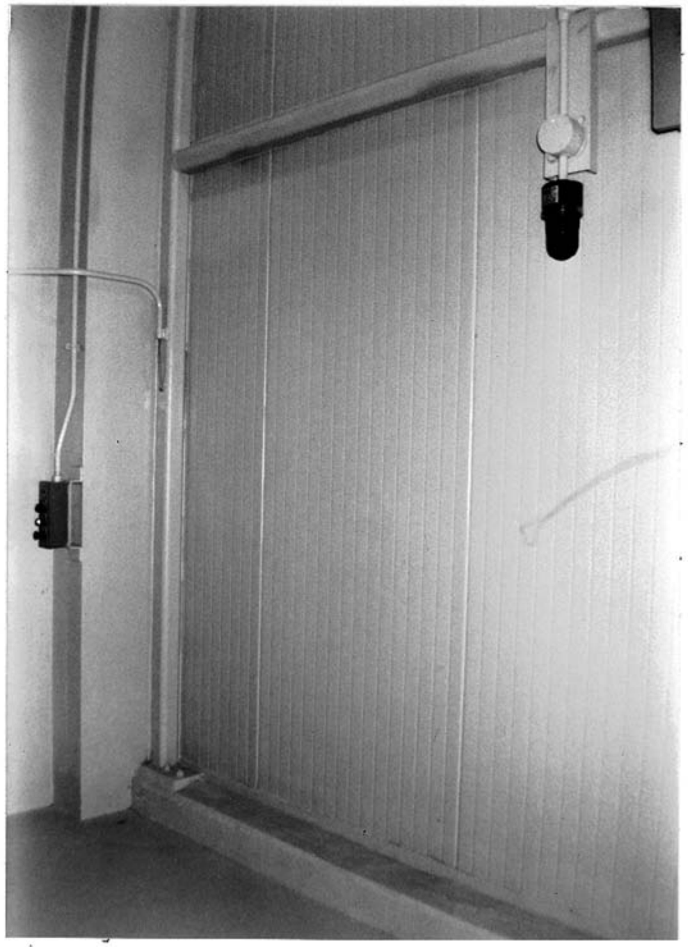


Fragmentation shield in ECR

Charcoal filter banks in foreground. MDB and pollution abutement system beyond.

Charcoal filter banks in foreground.
MDB and pollution abutement system beyond.

Composite panel wall system and tube steel framing.

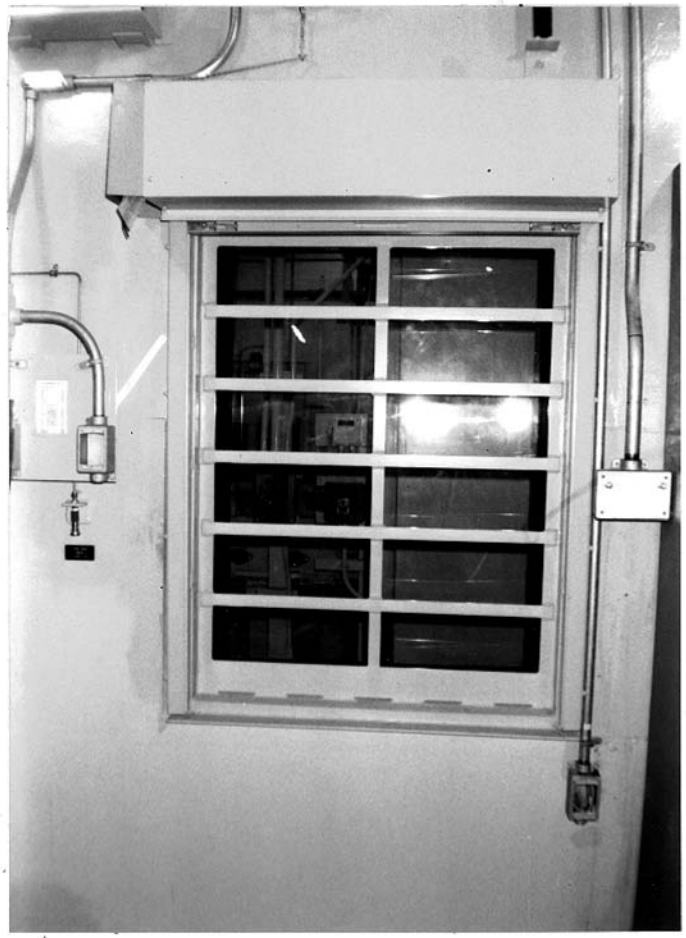


Composite panel wall system
and tube steel framing.

Composite panel wall system and framing at a door opening.

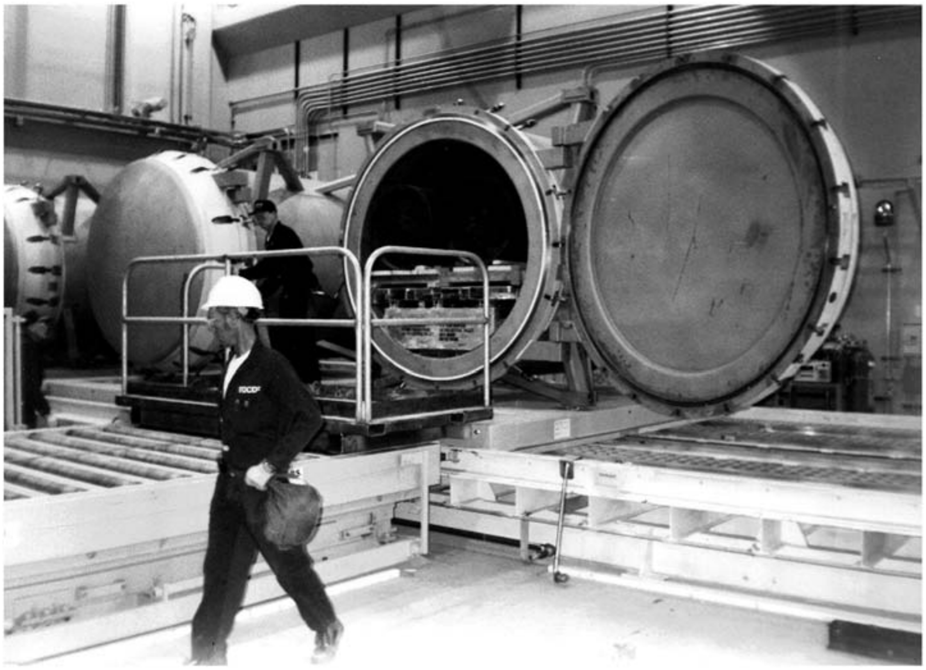
Composite panel wall system
and framing at a door opening.

Observation window in concrete wall showing security grille and fire shutter



Observation window in concrete
wall showing security grille
and fire shutter

Transport containers in Second Floor Unpack Area



Transport containers in Second Floor Unpack Area

Emergency exit and escape chute from Second Floor Unpack Area

Emergency exit and escape chute
from Second Floor Unpack Area

Emergency door showing signage, Security hasps and hardware trim.

Emergency door showing signage,
Security hasps and hardware trim.

Exterior side of an Airlock door showing signage, category of room, air hose support assembly and security hasps.

Exterior side of an Airlock door showing signage, category of room, air hose support assembly and security hasps.

Interior side of an Airlock door showing signage, air hose support assembly air loop, pneumatic power assist, magnetic lock, closer, door control switch and IDS switch.

Interior side of an Airlock door showing signage, air hose support assembly air loop, pneumatic power assist, magnetic lock, closer, door control switch and IDS switch.